stored up opportunities of intellectual and æsthetic culture. Selection without elimination involves no racial progress. He then puts this problem: "It would "seem, in fine, that if mental evolution in man be manifested rather in the pro- "gressive advance of human achievement than in progressive increment of human "faculty; if the developmental process have been transferred from the individuals "to their environment; if it be rather the intellectual and moral edifice that is un- "dergoing evolution, than the human builders that contribute in each generation a "few more stones to take a permanent place in its fabric; if there be thus no con- "clusive evidence that faculty is improving, but rather the opposite; if all this be "so, then it would seem that the ground is cut way from under the feet of those "who regard mental evolution in man as due to inherited increments of individ- "ually acquired faculty. Nay, more; if the average level be not rising, some ex- "planation must be demanded from transmissionists of this fact. For surely if "there be transmission of individually acquired increment, the average level of "faculty ought to be steadily rising."

The book, both for study and reading, is marked by charm of style, attractiveness of presentation, and soundness of philosophical view. There is a wealth of observation on animal life gathered in it, concisely and entertainingly told. All will draw intellectual edification from its perusal. T. J. McC.

VORLESUNGEN ÜBER THEORETISCHE PHYSIK. Von *H. von Helmholtz*. Band V Electromagnetische Theorie des Lichtes. Herausgegeben von Arthur König und Carl Runge. Hamburg. 1897. Pp. 370. Price, 14 Marks.

Helmholtz in his triple rôle of physiologist, physicist, and mathematician is perhaps sometimes forgotten as Helmholtz the educator. It may indeed be doubted whether any one American, dead or living, has ever furnished from the ranks of his own students so many investigators and instructors in physics for American institutions as has Helmholtz.

For a full quarter of a century, the royal university of Berlin was the attracting centre for Americans in search of opportunities in physics, mathematical or experimental. It was there, under the kindly eye and word of the master, that life-long inspiration came to many a student. The volume under review, therefore, is not without a peculiar personal interest for many of its English-speaking readers.

Forming, as it does, the fifth in a series of six volumes, it is nevertheless the first to appear, the lectures having been recorded in stenographic notes by a student during the last semester of their delivery. While the *Electromagnetic Theory of Light* stands as the title of the lectures, they cover really the whole ground of modern optics, both geometrical and physical. Parts III., IV., and V., treating of spherical waves, diffraction and geometrical optics, respectively, would stand intact on *any* wave-theory of light, being questions of kinematics, not of kinetics. It is when the real nature of luminous disturbances is considered, in Parts I., II., and

VI., that the electromagnetic theory is employed, and employed with marvellous lucidity.

It will be remembered that Maxwell, in 1865, sent to the Royal Society his prediction that light-waves would be found to be electric waves, travelling in the ether of transparent substances, and that the speed of light, in any given medium, would be found to depend upon the electric and magnetic constants of that medium. But it was not until the autumn of 1888 that Hertz, the favorite pupil of Helmholtz, succeeded in actually producing these electric waves, in measuring their speed, in reflecting, refracting, and polarising them; succeeded, in short, in proving *experimentally* the identity of light-waves and electric-waves. This investigation of Hertz was undertaken in response to a prize question set by Helmholtz for the Berlin Academy. In a very true sense, therefore, Helmholtz is one of the founders of the electromagnetic theory of light: and the volume before us is one in which a creator describes his own work; especially is this the case in the chapters on geometrical optics and dispersion.

To one of philosophic bent, no more instructive chapter in the history of physical science is to be found than that in which a great field of learning—light—is swallowed up, as a special case, in another great field—electricity. It forms a long stride toward a unitary view of nature, toward the goal of modern physics.

Each of the various parts of the subject which Helmholtz here handles have been discussed in various treatises, English and German, and, indeed, the whole subject is touched upon in certain compendiums of physics. But nowhere has there ever appeared a treatment at once so thorough, so elegant, and so exceedingly clear, as that under review. The mathematics which appear are not introduced as exercises in analysis, rather as tools in a master's hand. Each mathematical result receives a distinct physical interpretation. The word "theory," from its first appearance on the title-page to the end of the book, is employed only in its best sense —its original sense—to indicate not the hazy guess of a vivid imagination, but an attempt at a comprehensive survey and a concise description of facts.

A brief summary of the contents of the volume is the following. Our notions concerning the nature of light have been arrived at through at least four steps. First, the emission-theory of Empedocles in which the eye, as well as the object seen, emits the light. Second, the corpuscular theory of Newton, in which the self-luminous body is the sole source of emission. Third, the elastic-solid wave-theory of Fresnel. Fourth, the electromagnetic wave-theory of Maxwell.

It is to a complete description of optical phenomena in terms of Maxwell's idea that this first purely didactic volume of Helmholtz is devoted.

One hundred pages are first given to a study of the properties of electric waves. The beautiful parallel treatment of electric and magnetic quantities is preserved throughout. A clear grasp of the general phenomena of electricity is here demanded of the intelligent reader. The next hundred pages cover a rigid mathematical discussion of diffraction. It is here that the author explains what is, at once, the par-

adox and the *crux* of optical science, viz., the rectilinear propagation of light, and the fact that light can and does shine around a corner. The starting-point of this discussion is a remarkable generalisation of Green's Theorem—itself the most powerful theorem in mathematical physics—to include four independent variables, time being the one added to the usual three space-coordinates.

Geometrical optics is the subject of the third hundred pages, a very elegant chapter.

The remainder of the book goes to dispersion and polarisation, treated in terms of the electromagnetic theory. Much of the subject matter is the result of Helmholtz's own investigations concerning the mysterious connexion between ether and matter.

The appearance of these six posthumous volumes of mathematical physics, in addition to three volumes of *Scientific Papers* and two epoch-making treatises, cannot be contemplated without amazement at the changes which the genius of this one man has wrought on the face of modern science.

The ease with which he lays aside his seven-leagued boots and adapts himself to the intellectual wants of his hearers makes him a brilliant example to all teachers. While as an instructor in the elementary parts of his subject he was never a striking success, to investigators the mere mention of his name is an inspiration.

HENRY CREW.

OSTWALD'S KLASSIKER DER EXAKTEN WISSENSCHAFTEN. Vier Abhandlungen über die Elektricität und den Magnetismus (No. 13.) Von *A. Coulomb*. Pages, 88. Price, M. 1.80. Zwei Abhandlungen über die Wärme. (No. 40.) Von *Lavoisier* und *Laplace*. Pages, 74. Price, M. 1.20. Anmerkungen und Zusätze zur Entwerfung der Land- und Himmelscharten. (No. 54.) Von *J. H. Lambert*. Pages, 95. Price, M. 1.60. Ueber Kartenprojection. (No. 55.) Von *Lagrange* und *Gauss*. Pages, 101. Price, M. 1.60. Leipsic: W. Engelmann.

The four essays of Coulomb here reprinted are the most important of his seven fundamental memoirs on the laws of electricity and magnetism. The first two are devoted to the proof that the repulsions and attractions of electrified and magnetised bodies take place according to the law of the inverse squares, the third deals with the loss of electricity in such action, the fourth proves that the electric charge is distributed over bodies by its own repulsion, and that when in equilibrium it is always at the surface. The results form the basis of the entire mathematical treatment of magnetic and electrostatic phenomena as it has taken shape in the modern theory of potential, and until the researches of Faraday formed the sole basis. Revolution after revolution has taken place since then in electrical *theory*, but the *facts* established by Coulomb remain unchanged, and his investigations, therefore may be regarded as an exemplar of scientific procedure.

The memoirs of Lavoisier and Laplace are extremely important as marking